Copernicus and the Planets – limited elongation

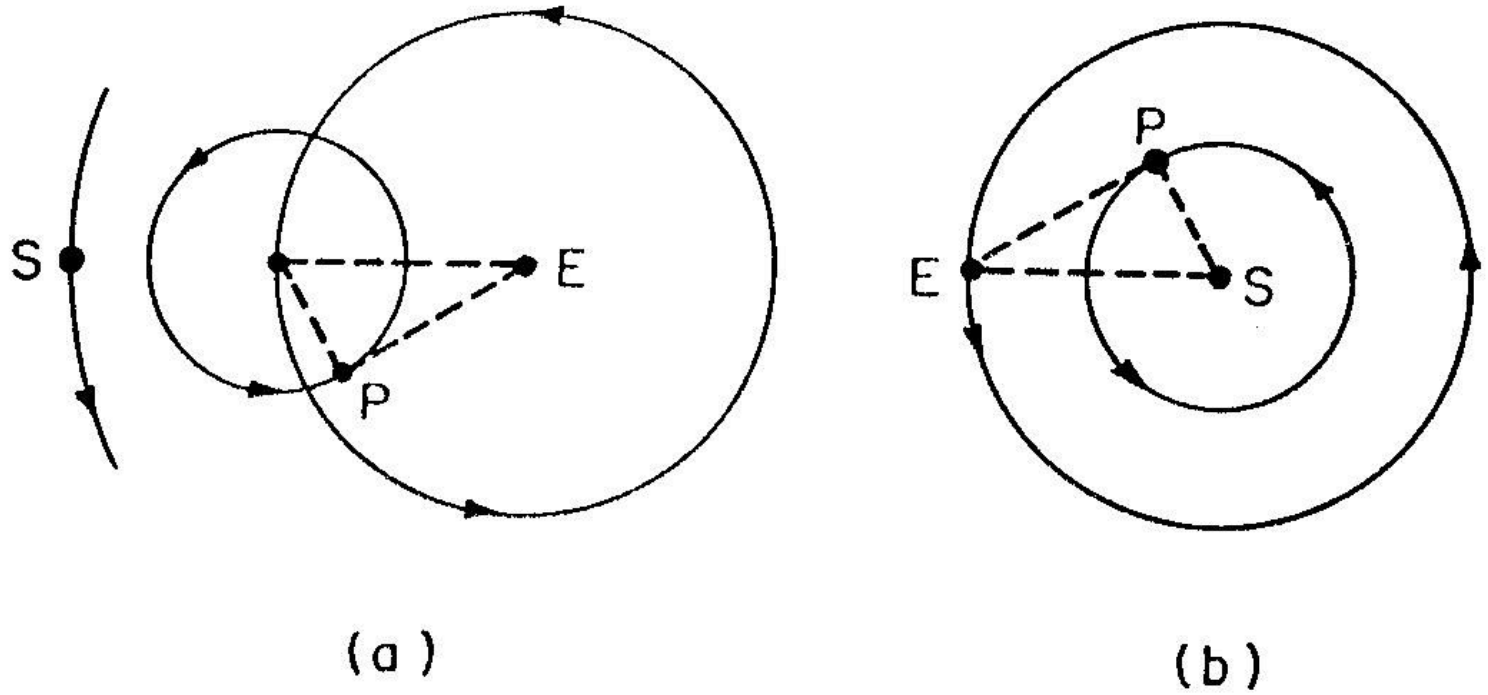


Figure 35. Limited elongation of inferior planets explained in (*a*) the Ptolemaic and (*b*) the Copernican systems. In the Ptolemaic system the angle between the sun, *S*, and the planet, *P*, must be restricted by keeping the center of the epicycle on the line between the earth and the sun. In the Copernican system, with the planet's orbit entirely contained by the earth's, no such restriction is necessary.

Copernicus and the Planets – limited elongation

- Again Ptolemy's account is a fix
- There is no reason why the earth sun and the centre of the epicycle should be collinear
- But in Copernicus, Earth is nowhere special
- Perfectly natural that some planets should be inferior
- And for them bounded elongation 'drops out'

Copernicus and the Planets – relative size of the orbits

- Remember that the order of earth, Mercury and Venus was completely arbitrary in Ptolemy's theory
- But in Copernican theory the order is completely fixed
- Indeed the relative sizes of the orbits of *all* planets is fixed

Copernicus and the Planets – planetary periods

- VENUS retrogresses every 584 days
- Retrogression means passing the Earth
- Earth travels 1+219/365 times round its orbit in 584 days
- Venus must have gone 2+219/365 times round its orbit
- T(V) x 949/365 = 584
- T(V) = (584x365)/949 = 225 days

Copernicus and the Planets – planetary periods

- MERCURY retrogresses every 116 days
- Earth moves 116/365 of its orbit in 116 days
- So to lap earth Mercury must move 1+116/365 of its orbit in 116 days
- T(M) x 481/365 = 116
- T(M) = (116x 365)/481 = 88 days

Copernicus and the Planets – relative size of the orbits

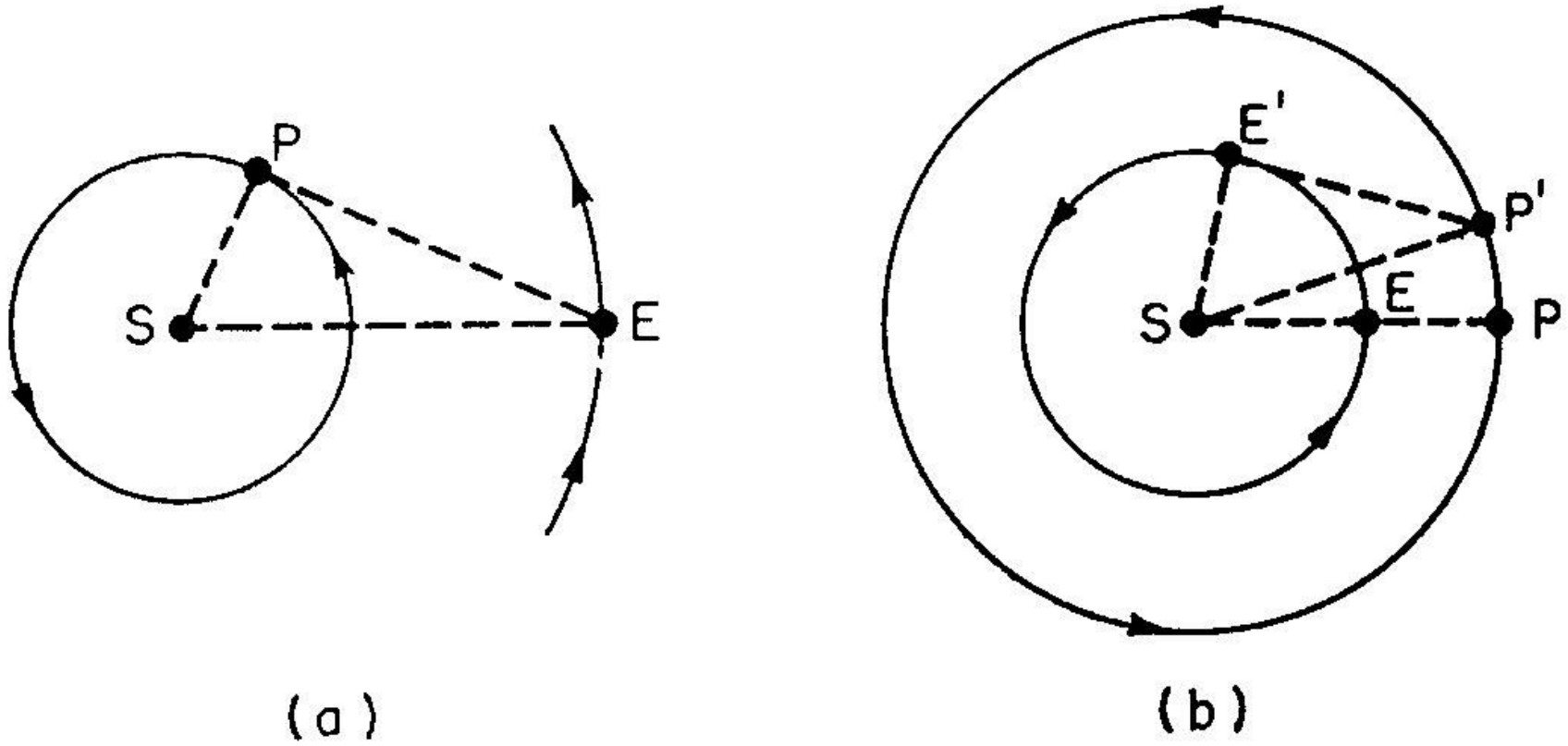


Figure 36. Determining the relative dimensions of orbits in the Copernican system: (*a*) for an inferior planet; (*b*) for a superior planet.

Copernicus and the Planets – relative size of the orbits

- Inferior planets
- SPE = 90^{o}
- SEP = angle of max elongation; and is measurable
- SP/SE = sin SEP
- SP = SE (sin SEP)

Copernicus and the Planets – relative size of the orbits

- Superior planet
- Suppose S, E &P are collinear at t
- (planet 180^{o} across ecliptic and in middle of retrogression)
- At some later time t', earth at E', planet at P' and SE'P' = 90^{o}

Copernicus and the Planets – relative size of the orbits

- ESE’/360 = Δt/365
- PSP’/360 = Δt/ period of P
- Hence P’SE’ can be determined
- And Cos P’SE’ = E’S/SP’
- So, SP’ = SP = E’S/ Cos P’SE’ = ES/ Cos P’SE’

Copernicus and the Planets – relative size of the orbits

- This is what he meant when he said that in his theory
- “ the orders and magnitudes of stars and spheres ..become so bound together that nothing in any part thereof could be moved from its place without producing confusion of all the other parts and of the universe as as whole.”

Copernicus and the Planets – relative size of the orbits

- And what he meant when he contrasted what his theory principally achieved compared to the Ptolemaic
- That they, unlike him, had been unable ‘ to discern or deduce the principal thing – namely the shape of the Universe and the unchangeable symmetry of its parts.’

Rationality and Revolution

- Copernicus himself and later luminaries like Kepler, Galileo and Newton were convinced by his sun-centred view
- Others of course resisted the change
- Were the revolutionaries rational and the stick-in-the-muds motivated by non-rational concerns?

Rationality and Revolution

- It is usually thought that the ‘revolutionaries’ count as rational iff the new theory was objectively superior to the old.
- But what exactly does this mean?
- Empiricists think it means something about how the two theories compare to the available evidence.

Rationality and Revolution

- Certainly in the Ptolemy/Copernicus case both theories can give correct accounts of all the observational evidence – one way or the other.
- Does this entail that there was no evidential reason to prefer one theory to the other?

Rationality and Revolution

- Let's think again about the relevant phenomena:
- Stars and sun – surely no reason to prefer one theory to the other
- (Though stellar parallax??)
- (And though '3rd motion'?)

Rationality and Revolution

- Planets:
- 1. Stations and retrogressions
- 2. Limited elongation
- 3. Variability of observed planetary periods
- 4. Order of planets

Rationality and Revolution

- In all four cases, Copernican account surely seems better.
- Is this because these accounts are “simpler”?
- Best way to think of them is, I believe, as genuinely *predictive* successes

Rationality and Revolution

- Notice that, in the stations and retrogressions case at least, the superiority only applies to the basic model – Copernicus's full account involves as many epicycles as Ptolemy's

Rationality and Revolution

- Have then these four striking ‘predictive’ successes
- But also:
- Ad hoc nature of full explanation of planetary movements
- Ad hoc nature of the third motion
- Temporarily untestable nature of non-observation of stellar parallax (phases of Venus)

Rationality and Revolution

- A lot of obscurity has been caused by assuming that a theory of scientific rationality has to imply that the preference between theories in the light of evidence is always a black-and-white affair.
- That it has to say, in the Copernicus case, that it was rational to accept the new theory warts and all.

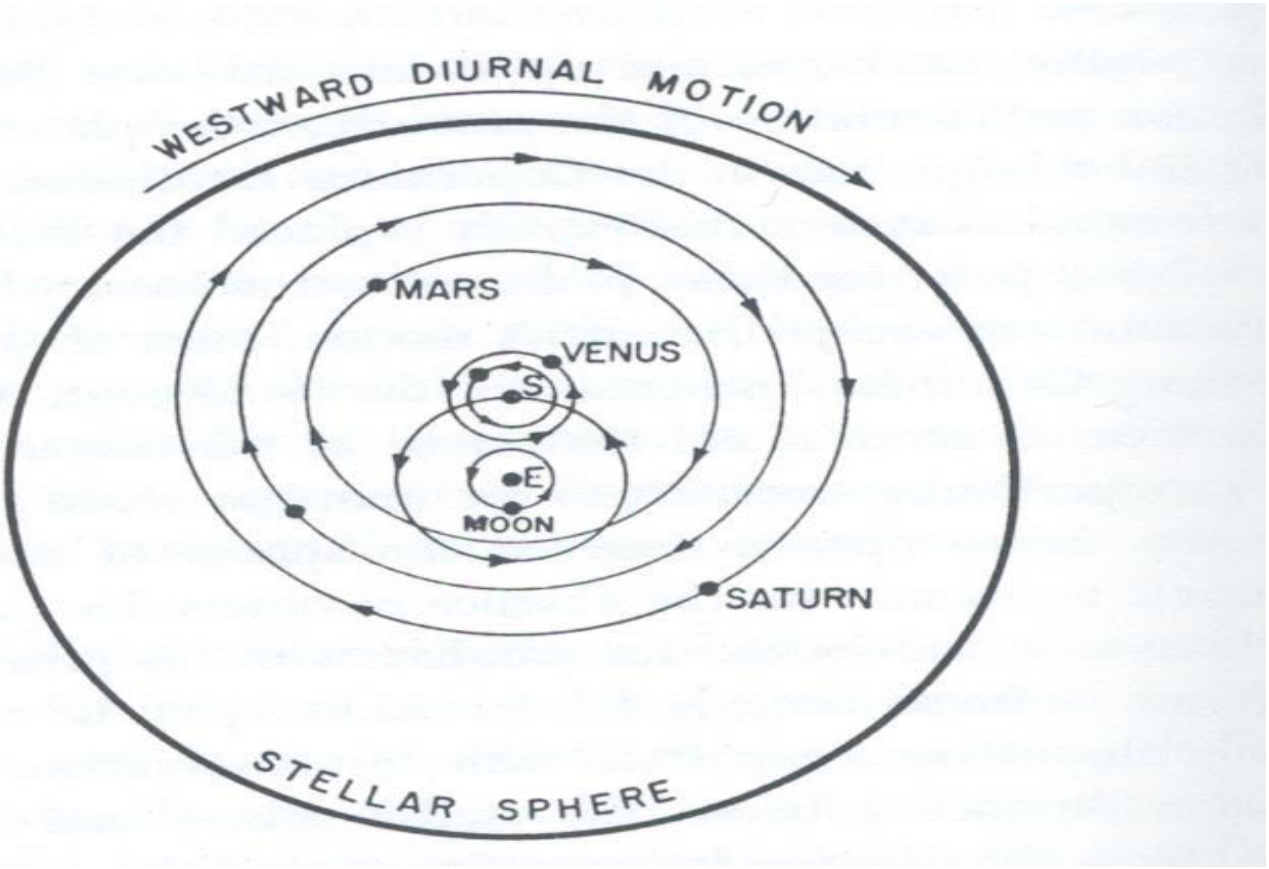
Rationality and Revolution

- WHY?
- Seems like the sensible view is that it scores real successes (enough to make you think that the basic assumption of a moving earth may well be correct)
- But that the epicycles and the third motion show that the theory is in need, at least eventually, of a major modification

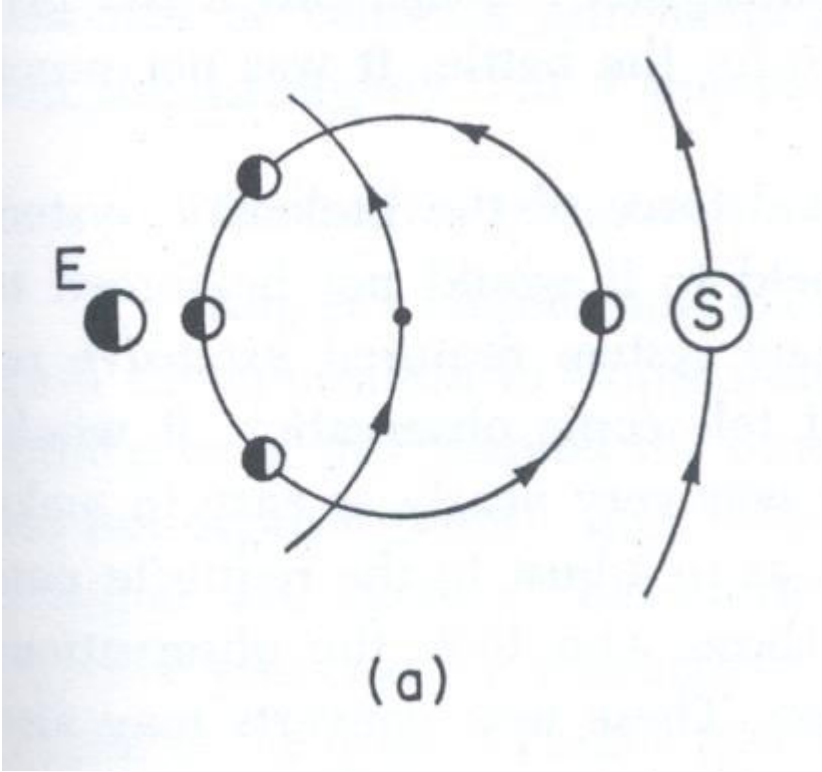
Rationality and Revolution

- This is exactly the sort of attitude that the ‘revolutionaries’ like Kepler, Galileo and Newton had!

The Tychonic system



Phases of Venus



Phases of Venus